Experimental Quantum Generative Adversarial Networks for Image Generation

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Abstract

Quantum machine learning is expected to be one of the first practical applications of near-term quantum devices. Pioneer theoretical works suggest that quantum generative adversarial networks (GANs) may exhibit a potential exponential advantage over classical GANs, thus attracting widespread attention. However, it remains elusive whether quantum GANs implemented on near-term quantum devices can actually solve real-world learning tasks. Here, we devise a flexible quantum GAN scheme to narrow this knowledge gap, which could accomplish image generation with arbitrarily high-dimensional features, and could also take advantage of quantum superposition to train multiple examples in parallel. For the first time, we experimentally achieve the learning and generation of real-world hand-written digit images on a superconducting quantum processor. Moreover, we utilize a gray-scale bar dataset to exhibit the competitive performance between quantum GANs and the classical GANs based on multilayer perceptron and convolutional neural network architectures, respectively, benchmarked by the Frechet Distance score. Our work provides guidance for developing advanced quantum generative models on near-term quantum devices and opens up an avenue for exploring quantum advantages in various GAN-related learning tasks.